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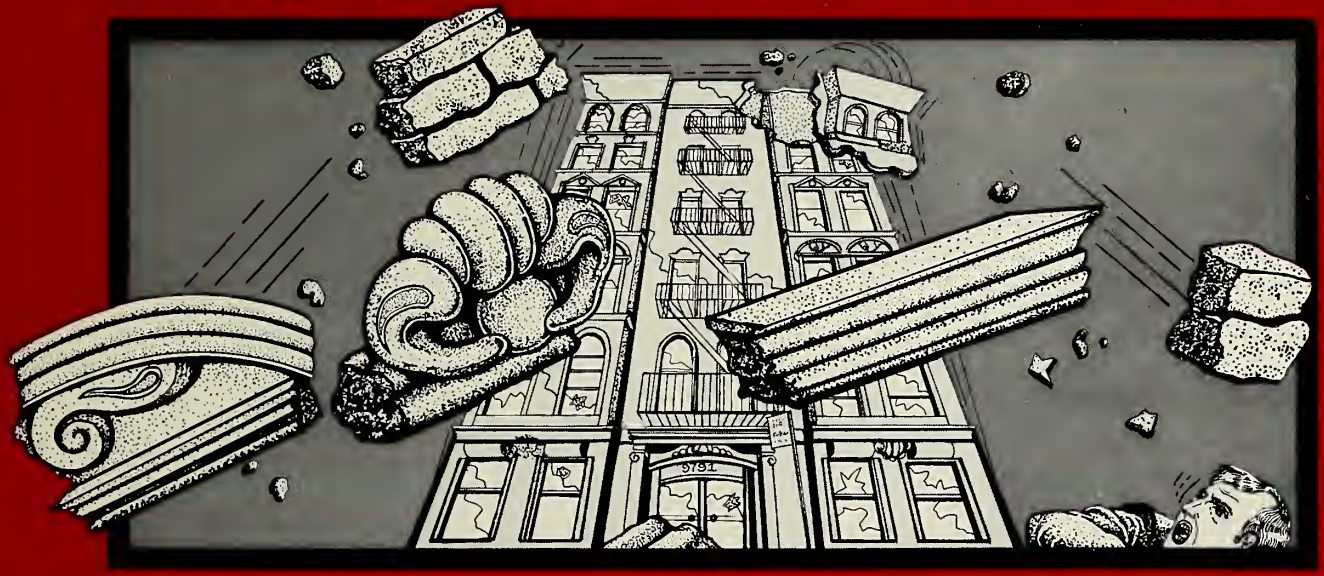

THE BIG QUAKE

WHAT LOCAL GOVERNMENTS CAN DO.

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BY TERRY MARGERUM
ABAG

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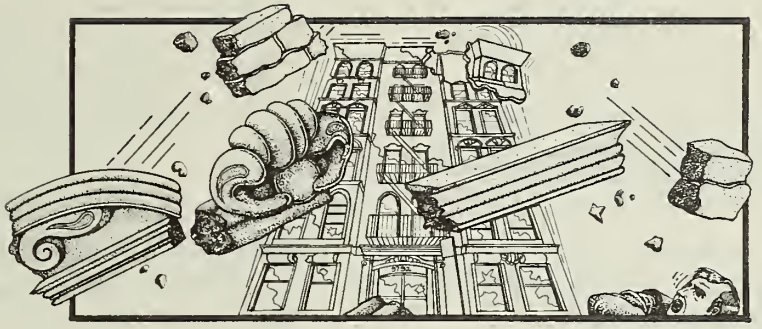

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MARCH 1980

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS

INTRODUCTION

If you are reading this, you may be present when the next great earthquake hits the Bay Area. Unless more is done soon to reduce earthquake hazards you will probably have a friend or relative who is killed or injured in that quake.

This report follows several months of extensive research. Many of its conclusions are as unavoidable as the earthquake itself.

- An earthquake comparable to that of 1906 will strike the Bay Area, possibly within the next 20 years.
- While most Californians know they live in "earthquake country", they do not realize how catastrophic a great quake will be. Nor are they fully aware of the earthquake hazards to which they daily subject themselves and their children.
- Little progress has been made in reducing the most serious earthquake hazards—dangerous old buildings, parapets, cornices and appendages.
- A great earthquake, if it hits during the daytime, will kill thousands of people, maybe scores of thousands. Property losses will be $30-50 billion.
- These potential losses could be greatly reduced if a political and financial commitment were made to do so—by both public and private sectors.
- The costs of reducing earthquake hazards are high, but so are the costs of inaction. In fact, over the long term money would be saved by preventive steps to reduce hazards.

This report describes:

- the likelihood and consequences of a major Bay Area earthquake;
- what's being done to reduce hazards;
- why more isn't being done;
- what local government can be doing;
- state and federal legislation that would help reduce hazards;
- resources and references

IT WILL HAPPEN

Thousands of people killed in a few seconds is going to blow the lid off this country, and it's going to happen.

Karl Steinbrugge, California Seismic Safety Commission.

Inevitably, and possibly before the year 2000, the worst natural calamity in North American history will strike California. Both the Bay Area and Los Angeles straddle the powerful San Andreas fault system. Both are criss-crossed by numerous less famous faults. Both are overdue for what seismologists call a "great" earthquake, that is, higher than 8.0 on the Richter scale.[1] Such warnings have come from experts in the earthquake sciences.

The U.S. Geological Survey (USGS) estimates a 70% chance of a great earthquake on the San Andreas within 30 years. USGS scientists are not alone in these expectations. In fact it's hard to find an authority who takes issue with such a prognosis.

Of course, California has had earthquakes before, some of them big. However, with the exception of San Francisco in 1906, California's major cities have been spared great earthquakes. A recent National Science Foundation report (quoted in John Fried, *Life Along the San Andreas*, 1973, p. 7) underlined how lucky we've been:

"It is reasonable to expect a maximum intensity earthquake in the San Francisco Bay Area every 60-100 years."[2]

Institute for Governmental Studies, Berkeley (1971).

"Between 1970 and 2000 we may expect a major earthquake in the San Francisco Bay Area of magnitude 8 Richter and duration of more than one minute."[3]

Dr. Tappan Munroe, University of the Pacific (1971).

"The coming San Francisco earthquake may well be the greatest catastrophe in the history of this country."[4]

Dr. Eugene Haas, University of Colorado (1977).

The forecast for Los Angeles is equally dire.

"This (the Southern) portion of the San Andreas fault has apparently been locked since the great 1857 Fort Tejon earthquake. Many geologists and seismologists believe that a great earthquake is likely to occur on this portion of the San Andreas fault, and in the not too distant future–perhaps before the end of this century."

California Geology, April, 1977.

Indeed, all of California has been put on notice.

"The chances of a great earthquake in California in the next 10 years are 50-50."[5]

Dr. Bruce Bolt, Director, University of California Seismology Lab, Berkeley, (1979).

[1] The highest rating is 8.9
[2] IGS Report on *Earthquakes and Public Policy*, 1971.
[3] *Economic Analysis of Natural Hazards*, Tappan Munroe, University of the Pacific 1971.
[4] *Reconstruction Following Disaster*, by Haas, Kates et al, 1977.
[5] In a speech to California Seismic Safety Commission, April 12, 1979.

"Just in the 2nd quarter of this century 350,000 have died in earthquakes.[6] The U.S. has been extraordinarily lucky so far. Less than 1200 persons have died in American earthquakes even though the U.S. has had several great earthquakes. The biggest occurred in the 19th century when the local population was dispersed and great modern ones have taken place in as yet sparsely populated parts of the country. But it is clear that someday–perhaps soon–the relentlessly increasing population curve and the earthquake curve will cross."

In other words sooner or later our luck will run out.

"...sooner or later our luck will run out."

Photo courtesy of R. Brown, U.S. Geological Survey

This means that most of us will be present when the San Andreas finally erupts. How bad will it be? Here is what the experts[7] expect to happen.

Death and Injury

In a great earthquake people will die in a number of ways—freeway collapses, drownings in beach areas, landslides, fires, spilt gases and chemicals, etc. With the possible exception of flooding (due to dam failure), the greatest dangers to life will be falling debris (parapets window-glass etc.) and partial or total collapse of older buildings in urbanized areas.

Collapsing Buildings

Statewide there are about 100,000 hollow-tile or unreinforced buildings built before 1933,[8] which can be expected to collapse in even a moderate earthquake. Also many buildings constructed later will not withstand a major quake either because they weren't built properly (codes sometimes are unenforced) or because they were built in locations which are hazardous due to poor ground conditions or proximity to faults.

In San Francisco alone more than 60,000 people live in structures likely to collapse in a moderate earthquake. Of the city's nearly 300 highrises (8 or more stories) Henry Degenkolb (a national authority on earthquake engineering) estimates that 15–30 will collapse and 50–100 will be severely damaged. Although "the City" has the worst problem, it is not alone. Berkeley and Oakland also have many hazardous buildings. Much of Hayward's central business district is subject to collapse and parts of San Jose are on ground that performed very poorly in the 1906 earthquake. In addition to deaths from collapse, hundreds, maybe thousands could die in fires in these older buildings.

Parapets and Cornices

In a great earthquake falling parapets and cornices will become lethal missiles, especially in downtown areas. "This is the biggest single urban hazard," declares Degenkolb. "It has happened at every major quake location I have visited."

Once again the greatest hazards are in San Francisco, but Berkeley, Oakland, and other cities have sizable problems, too. Peter Yanev, author of *Peace of Mind in Earthquake Country,* estimates that Berkeley may have a thousand buildings with dangerous appendages, mostly on Telegraph, College and Shattuck Avenues.

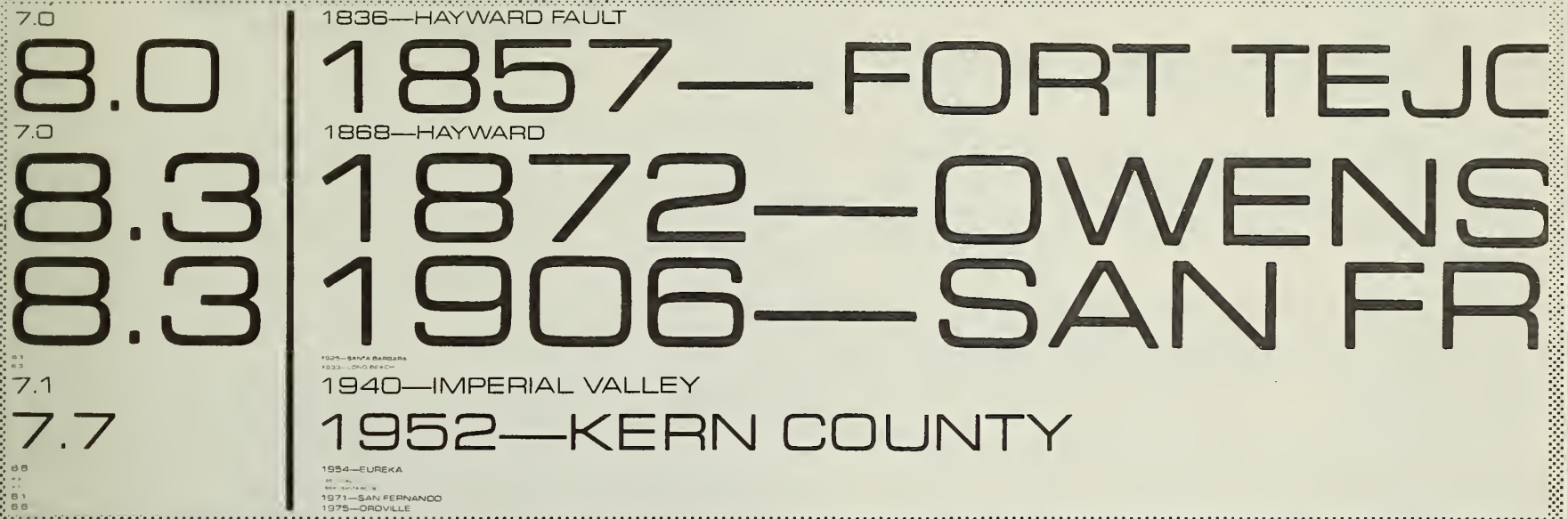
[6] This does not include the loss of nearly a million people in a 1977 quake in China.

[7] One of the most authoritative sources is the 1972 *Study of Earthquake Losses in the San Francisco Bay Area* by the National Oceanic and Atmospheric Administration of the U. S. Department of Commerce. A similar study was done for Los Angeles.

[8] In 1933, after the Long Beach Earthquake, building codes were strengthened in many parts of the state.

How Big is Big?—Measuring Earthquakes

Chart 1



Magnitude

The magnitude of an earthquake is a measure of the amount of energy released by the quake. Magnitude is measured on a scale devised by Dr Charles Richter On this logarithmic scale each whole number represents a magnitude of energy release roughly 31 times the next lower number Thus an earthquake measuring 7 on the destructive scale releases 31 times more destructive energy than a magnitude 6 earthquake.

The major destructive quakes in California during the last 150 years are listed above. The size of the text which identifies each earthquake reflects the magnitude of the quake. Clearly California has not seen a truly major earthquake in the last ½ of those 150 years!

Intensity

Intensity is a measure of the effect rather than the energy release of an earthquake. The measurement is necessarily subjective as it is based on personal observations and thus reflects local conditions Two intensity scales are commonly used—the San Francisco scale and the Modified Mercalli scale. Their relationship is illustrated below.

Intensity scales are useful in mapping the effects of previous earthquakes or, in earthquake-prone areas, the likely effects of future quakes. Figure 3 on Page 18 is an example of such a map prepared for the Bay Area

San Francisco Scale	Modified Mercalli Scale
Very Violent—A	XII—Massive Destruction
	XI—Utilities Destroyed
Violent—B	X—Most Small Structures Destroyed
	IX—Heavy Damage
Very Strong—C	VIII—Moderate to Heavy Damage
Strong—D	VII—General Non-structural Damage
Weak—E	VI—Felt By All People

Loss of Life

How many people are killed and injured will depend upon factors other than the magnitude of the earthquake.

First, there's the time of day—noontime and the rush-hours are the worst times; the best time would be early morning, before dawn, when most people are at home in bed.

Second, is it a wet or dry season?—Rain-soaked earth is more prone to landslides, ground shaking, and liquefaction; and dry conditions make fires more likely.

Has the earthquake been predicted?—In a *practical* sense, that is. Strictly speaking, we already know that a great quake is imminent but such vague predictions are not very useful. It is not likely that earthquake prediction will have advanced enough to be of much value before the next great earthquake.

Have the known hazards been reduced or eliminated?—Much could be done to reduce loss of life. For example, Los Angeles' parapet ordinance, enforced since the early 1950's, saved many lives in the 1971 San Fernando earthquake.

If one assumes a daytime quake (between 7 a.m.–7 p.m.), no prediction, and our current rate of progress in reducing known hazards, death estimates for a great earthquake on either the San Andreas or Hayward faults are frightening.

The estimates range from six thousand to several hundred thousands. The previously cited NOAA report[9] (based on 1970 Census data) estimates 10,360 and 6,650 for great earthquakes on the San Andreas and Hayward faults. These estimates exclude deaths from dam failure.[10]

Serious injuries are expected to be four times as numerous, and hundreds of thousands will sustain minor injuries.

The most pessimistic estimate was made in a 1977 book *The San Francisco Earthquake* by Gordon Thomas and Max Witts. They predicted as many as 350,000 dead and injured.

It is hard to conceive of such a tragedy, but until we face its likelihood our inaction makes it more likely. Such outcomes are avoidable, as Dr. Charles Richter told the U.S. Senate committee investigating the San Fernando quake. (Hearings before the Senate Committee on Public Works, June 10-12, 1971, p. 22):

"It should be more generally understood that earthquake losses are largely unnecessary and preventable. In the whole of past history something like 90% of the loss of life in earthquakes, and a major fraction of the destruction and economic loss, has been due to the failure of weak structures, such as would never be erected under any modern system of building regulation and inspection.—"

"It is hard to conceive of such a tragedy, but until we face its likelihood our inaction makes it more likely."

Photo courtesy of U.S. Geological Survey

[9] *A Study of Earthquake Losses in the San Francisco Bay Area*, U.S. Department of Commerce, 1972.

[10] These are always calculated separately because they distort the problem. For example, 46 people were killed in the 1971 San Fernando quake. Had the Van Norman Dam collapsed—as it almost did—80,000 lives would have been in jeopardy. In the Bay Area dam failures could endanger 30,000.

Right After The Big Quake—What to Expect

Chart 2

People

- Thousands on streets and sidewalks bombarded with glass, parapets, and debris
- Thousands stranded in high rise buildings because stairwells and elevators have failed
- Some people in beach and pier areas swept out to sea
- Over 30,000 persons homeless

Communications

- Most commercial radio and T.V. facilities out for 24 hours in counties near the epicenter

Transportation

- Railroad service out indefinitely
- 25–50% of Bay Area freeways impassable; some collapses of elevated freeways
- BART service disrupted in many places; the Trans-Bay tube out of service indefinitely
- All Bay bridges out of service indefinitely; thousands stranded on them
- One or more major airports out of service due to ground failure of bayfill; and they will also be inaccessible due to highway failures
- Small communities along the coast isolated due to landslides and road failures

Medical Facilities

- The total capacity of the hospital system cut in half due to structural and system failures
- More than a thousand physicians and surgeons unable to reach their offices
- 60–70% of all medical supplies lost or useless
- 40% of all major hospitals were built before 1933 and many of these will be severely damaged
- Nearly a third of the blood banks out of order for several days

Utilities and Public Services

- 50–60% of all telephones out of order for at least a few hours
- In an earthquake on the Hayward fault 95% of the East Bay's water will be cut off for 24 hours; hillside areas east of the fault will be without water for several days; problems will be less severe if the quake is on the San Andreas, but a 50% reduction is likely
- General power failure; half of all service connections out for 24 hours; these percentages will be higher in densely populated areas
- A Hayward quake would also cause major damage to natural gas lines, disrupting East Bay service for an extended period
- 2/3 of all raw sewage discharged into the Bay until repairs are made.

Economic Loss

It is also hard to comprehend the economic impact of a great earthquake on the Bay Area. One estimate (Edgar L. Jackson and Tappan Mukerjee, "Human Adjustment to the Earthquake Hazard of San Francisco, California," in Gilbert F. White, ed., *Natural Hazards: Local, National, Regional,* Oxford University Press, 1974, p. 162) is that a 1906 magnitude earthquake in the Bay Area

> ***"could cause losses equal to 3–5% of the U.S. Gross National Product or 1/3 of the total personal income of the state of California. The damage figures do not include the decline in economic opportunity caused by falling wages, profits, rents, taxes, and production."***

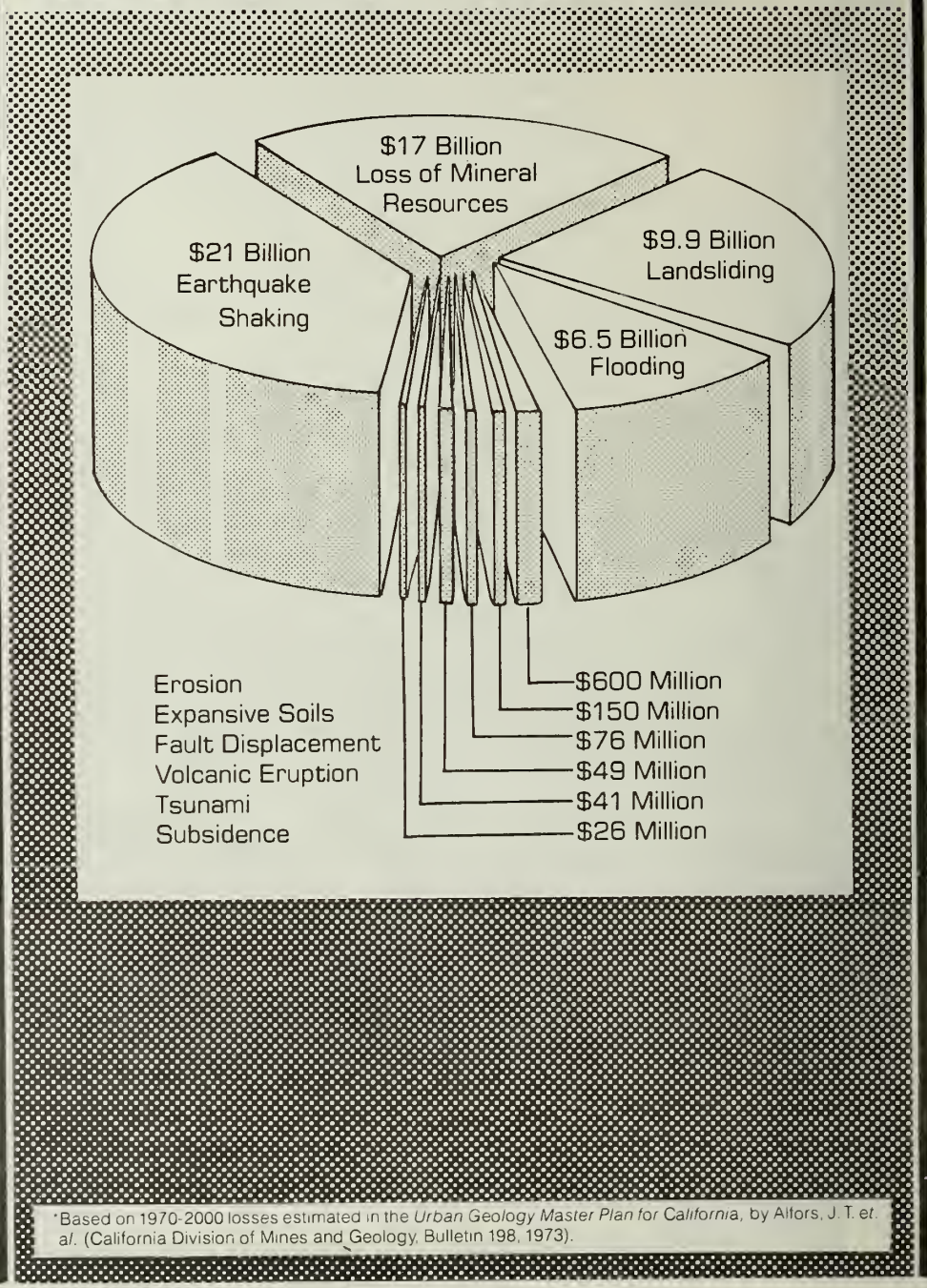
More conservative estimates range from $30–50 billion exclusive of secondary impacts such as reduced investment, interrupted production etc.

Some people argue that the Federal government will finance the reconstruction and recovery after a big quake. Why invest State and local money now, when massive Federal assistance will be available after the quake? There is an appealing logic to this plea. After all, for Alaska the 1964 earthquake was an economic boon second only to the North Slope oil. This is a rather perverse and unintended incentive in the Federal Disaster Relief Act, but it exists. However, the Alaskan analogy is not relevant. The 1964 event, was indeed a great earthquake the kind the Bay Area can anticipate, **but** it occurred in a very, very sparsely populated area. (The population of the entire state of Alaska in 1964 was under 300,000, less than the city of Oakland today.) Consequently the attendant economic loss was miniscule compared to what would happen in an intensely urban area. **In fact, the 1971 San Fernando quake (an earthquake approximately 1/1000 the size of the 1964 Alaska event) on the fringe of the L.A. metropolis caused greater economic loss than the 1964 Alaska quake.** Federal aid did not even cover all the losses from that quake.

California will receive much Federal aid following a great earthquake—but not nearly enough to cover the losses. The Federal government cannot and will not underwrite California's lack of prevention, even though some Federal programs are a disincentive to such preventive medicine.

These numerical estimates of the death and destruction which will accompany a great quake are frightening but don't really help understand what things will be like immediately after the earthquake strikes.

Anticipated Losses Due to Geologic Hazards in California to the Year 2000.* Chart 3



*Based on 1970-2000 losses estimated in the *Urban Geology Master Plan for California*, by Alfors, J. T. *et. al.* (California Division of Mines and Geology, Bulletin 198, 1973).

WHAT'S BEING DONE?

"–We now have the knowledge to substantially reduce earthquake risks. But the potential for earthquake catastrophe continues to increase as population concentrates in urban centers and hazardous buildings remain in use."

Senator Alfred Alquist in Joint Seismic Committee Final Report, 1974.

Numerous plans for reducing California's vulnerability to earthquakes have been proposed, none more thorough than that written by Senator Alquist's Joint Committee. Unfortunately few of the Committee's recommendations have been implemented, and those that have were often "watered-down." Chart 4 summarizes the status of the Joint Committee's program.

Some progress has been made. After more than 40 years, the Field Act's safety objective for schools is nearly achieved. New hospitals will be safer thanks to the Hospital Safety Act, and dams and freeway overpasses are being made safer since the 1971 San Fernando earthquake. Also there is increased public and governmental awareness of earthquake hazards resulting from such legislation as the Special Studies Zones Act and the seismic safety element requirement. Media attention to recent earthquakes and the emerging science of earthquake prediction have also helped.

But it is doubtful that the people of California especially in older cities, are any less vulnerable to earthquake hazards than they were 5, 10, or 20 years ago. In fact, in many ways the urban environment is even more hazardous. How can this be so? Because of the continuing concentration of population in urban areas and the failure to reduce significantly the daily use or danger of existing hazardous buildings.

Some Important Steps Have Been Taken ***Page***

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Review of Alquist Joint Committee Recommendations

More than 4-½ years ago Senator Alquist's Joint Committee on Seismic Safety published its final report[11] developed by a Committee of more than 70 expert advisors. The report's thorough recommendations developed after 4 years of intensive study serve as a useful benchmark for measuring California's progress toward greater seismic safety. A review of those suggestions unhappily reveals that, with a few notable exceptions, the Joint Committee's recommendations have not been implemented. A brief status report on their major recommendations follows.

1—Establish a Seismic Safety Commission. A commission reasonably similar to that suggested was created. However, it was not "empowered" to order compliance with State (seismic safety) standards, or given approval authority over seismic safety measures adopted by State, local and regional agencies. Some people argue also that the Commission is handicapped by having such a small staff (only 5 professionals). The Governor's proposed 1979-80 budget contained no funds for the Commission. Although funding was restored, it illustrates the vulnerability of the Commission.

2—The State should make sure that local governments prepare and enforce seismic safety elements as a part of their general plans. The Commission has reviewed a selected sample of the elements and reported that over 20% of the State's jurisdictions have no element, and that it's too early to tell if local government is implementing them. Currently the State has no way of ensuring compliance or implementation.

3—Employ land use controls to prevent new building activity that would create new seismic hazards. There has been no real progress. As In 1978 the Legislature made minor changes in the geologic study and disclosure requirements for subdivisions. The change only affects about one-fifth of the State's counties.

4—Amend the State Community Redevelopment Act to provide that seismic and geologic hazards be considered as "blighting" conditions. This would allow use of urban renewal funds to mitigate hazardous structures. No progress to date.

5—Local governments should develop post-earthquake redevelopment and reconstruction plans. The Committee hoped that such planning would help avoid the "Anchorage experience," where political and economic pressures forced a frantic reconstruction which in many instances repeated the land use mistakes which led to tragic losses in the 1964 earthquake.

6—Legislative and administrative guidelines should require that consideration of hazards and seismic safety be included in the EIRs. The guidelines have not changed but this is often done in practice by the State, ABAG, and many local governments.

7—State should regulate small utility systems which serve Planned Unit Developments to insure they can cope with disaster situations. No progress to date.

8—Revisions of Buildings Standards and Codes—These kinds of regulations are periodically improved, drawing from lessons learned in recent earthquakes around the world. This has been primarily the result of efforts of various professional groups. With regard to existing hazardous buildings, some argue that the requirements that rehabilitated buildings must meet the latest code is a strong disincentive to owners repairing the buildings, and that a slightly more relaxed requirement would result in more rehabilitation and hence greater safety. Legislation allowing lower standards for rehabilitating older buildings was enacted in 1979.

9—Enforcement Measures—The Joint Committee found that lack of competent building inspectors and code enforcement at the local level were serious barriers to increasing seismic safety. This is still true today. In talking with several experts two of the first things they mentioned as needing to be done were stricter code enforcement and upgrading the competence of local government building department staff. In larger jurisdictions the

[11] Published January, 1974

staffing problem is usually inadequate numbers and in smaller ones competing demands on scarce staff means not enforcing the law requiring local governments to use the UBC. Some local building inspectors have asked the State to improve enforcement of the law, but this has not occurred.

10—Hazardous Buildings—The Joint Committee report stated in January, 1974 that "The California Commission on Seismic Safety should be authorized and directed to proceed immediately with a program of hazardous building abatement . . . As an adjunct (to this program) the State should require local jurisdictions to formulate and enforce regulations leading to the elimination of unsafe parapets, especially those on earthquake-resistant buildings." In terms of making California a safer place to live and work, no two actions could do more than these. Yet 5 years later no progress has been made. The costs and socio-economic consequences of a full-scale hazardous building program have seemed prohibitive, so the lack of movement is understandable even if unjustified in terms of public safety. However, the cost of the removal or structural correction of dangerous parapets is not nearly so prohibitive. Indeed the city and county governments of Los Angeles (and a few other jurisdictions) have enacted and enforced parapet ordinances. Their citizens in public streets and sidewalks are much safer as was clearly demonstrated in the 1971 San Fernando quake where the parapet law saved many lives and money. The Commission was also to conduct an inventory of potentially hazardous buildings, other than the pre-1933 unreinforced structurces, in order to determine the magnitude of that problem. This has not been done either.

The problem of hazardous buildings **is** a top Commission priority and has been the subject of numerous workshops. The Commission issued a major report on the issue in 1979; and SB 1279 enacted in 1978 authorized the Commission to prepare an action plan for hazards reduction. Major legislation on reconstruction was enacted in 1979 (SB 445 and SB 555).

11—Critical/High Exposure Facilities—

In 1978 the Legislature amended the Hospital Safety Act to require certain hospital equipment to be anchored down so that it is more likely to be functioning after an earthquake. But the Legislature the same year rejected bills to require the State to investigate and abate hazards associated with small nuclear handling facilities. SSC staff estimate that about 30 of 1,500 such facilities are dangerous.

Progress has been made with regard to State review of the design adequacy of Federally-sponsored dams and reservoirs. This has been accomplished through a State memorandum of agreement with the Federal Bureau of Reclamation, which assures the State role in the review/approval process.

12—Local Disaster Response Plans—The Joint Committee recommended that these plans be mandated by State law, and that there must be formal State procedures for their review and approval. This has not been done. Such plans are not required. Although many jurisdictions have them the State Office of Emergency Services provides technical assistance and review, if requested.

The Joint Committee also suggested that government agencies and large non-public organizations conduct annual disaster drills. Only hospitals are required to have such drills.

Emergency evacuation plans are required for jurisdictions in flood inundation areas, but the law is not being strictly enforced or complied with.

13—Research and Development—Finally, the Joint Committee advocated increased State funding for emergency and public safety services, and for research into a number of earthquake-related fields. To date none of these ideas have been implemented.

Statewide Actions

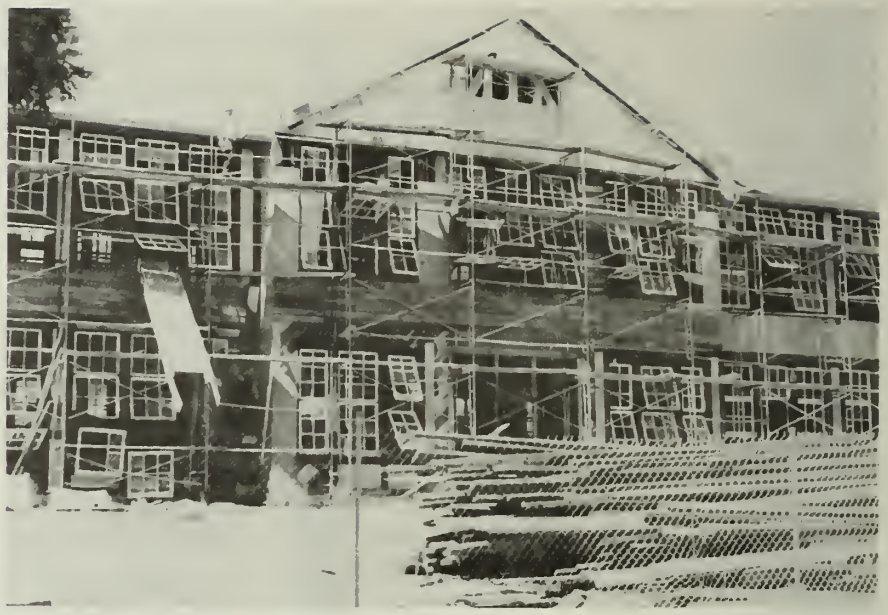
Public Elementary and Secondary Schools

In the 1933 Long Beach earthquake many school buildings were severely damaged. Had they been occupied at the time of the quake many children would have been injured or killed. This powerful lesson provided the impetus for a series of legislative, legal, and administrative actions[12] beginning with the Field Act, aimed at ensuring the seismic safety of public school buildings in California. This process is succinctly summarized in a recent White House Report:

> ***"In short, progress resulted from the combined effects of State financial assistance, fixing of school board member's personal liability for failure to exercise due care, the requirement of safety inspections by a deadline, and the forced abandonment of unsafe buildings. Progress was inadequate until these factors were working together, whereupon results began to be seen; but the entire process of identifying and repairing or retiring unsafe schools took more than 40 years."***

Earthquake Hazards Reduction: Issues for an Implementation Plan (1978).

Subsequent earthquakes have repeatedly demonstrated the validity of the Field Act's standards.



"...the entire process of identifying and repairing or retiring unsafe schools took more than 40 years."

ABAG photo by Ross Turner

Hospital Safety Act

Using the Field Act as a guide, the legislature in 1972 passed a law requiring that new hospitals, and substantial additions to existing hospitals be built to earthquake-resistant standards. This is accomplished through plan review and on-site inspection. Like the original Field Act this legislation is not retroactive and therefore does nothing to increase the safety of existing hospital facilities. This is a major problem for the Bay Area where 40% of all major hospitals were built before 1933. Furthermore in the East Bay thirteen hospitals are on or very near active faults. (See map on next page).

The Hospital Safety Act was an important step, but it is not nearly adequate to assure the reasonable safety of patients, who are after all a quasi-dependent population, not fully able to protect themselves.

[12] The major steps were: Field Act (1933), Garrison Act (1939), Green Acts (1967, 1968 and 1974) and an Attorney General's opinion on the tort liability of board members (1966).

Published January, 19

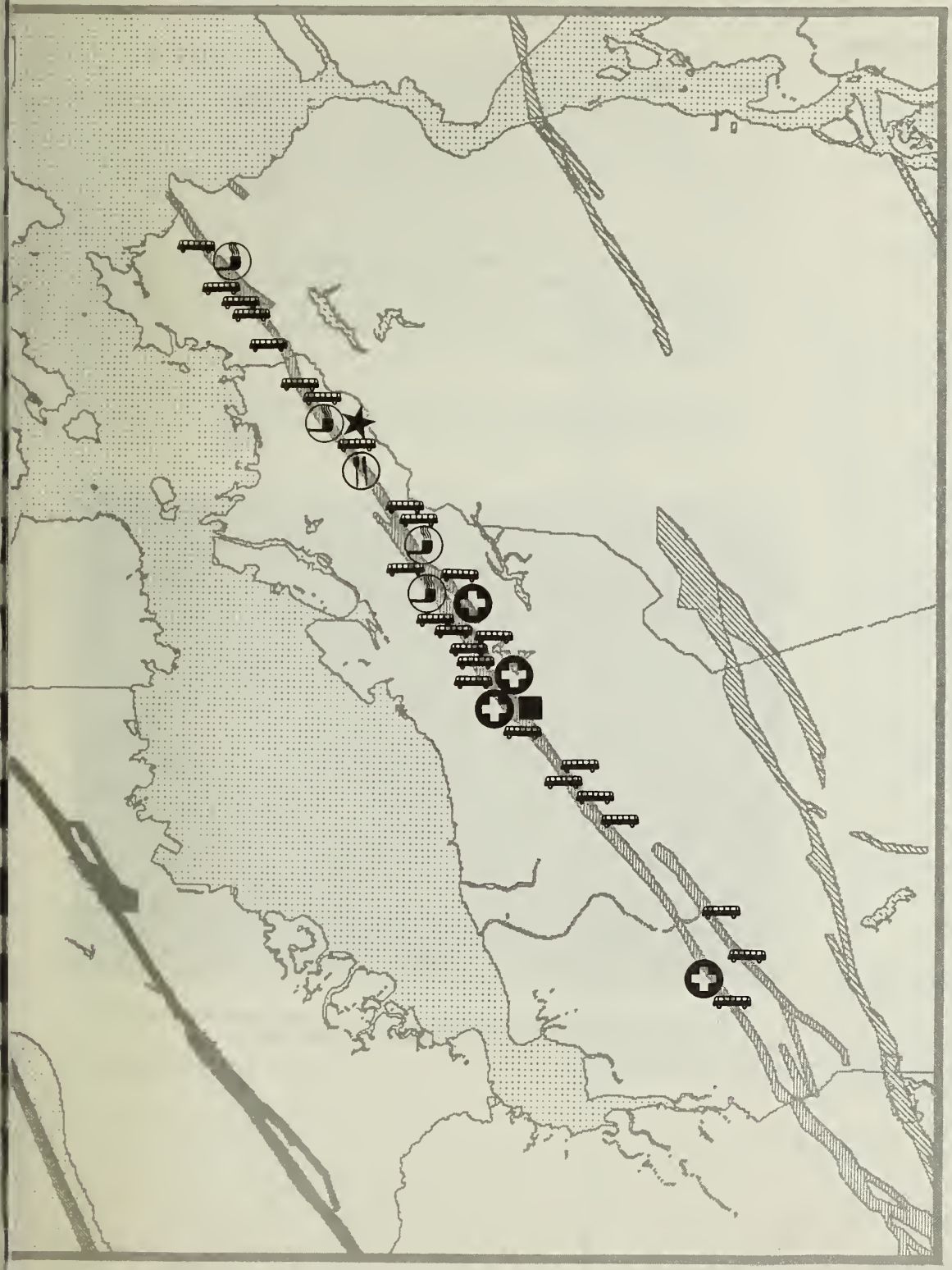


Figure 1

Public Buildings on the Hayward Fault

This map illustrates the number of high-occupancy public structures sitting astride the Hayward Fault.

Public School

College or University Building

Hospital

Jail

Stadium

Hotel

Alquist-Priolo Special Studies Zone Act

Passed in 1972, this law's purpose is to prevent construction on or very near active faults, which could tear the structures apart or damage their foundations by surface movement or fault creep. The act requires "special study" of developments proposed within the zone. The original act designated four known active faults and permits the State geologist to designate others,[13] which he has on occasion. It also requires full-disclosure, i.e., when someone buys a structure within a designated zone, they must be so informed. The act is limited to problems associated with surface faulting rather than geologic hazards in general.

The act is considered partially successful. It has retarded development in some exceedingly hazardous areas, but a Seismic Safety Commission survey revealed much local government confusion over its meaning in practice, and skepticism over the enforcement of the disclosure requirements.

Dams

Because of the near failure of the Van Norman Dam in the 1971 San Fernando earthquake, significant safety improvements were initiated by State and local authorities. These programs require the identification and abatement of unsafe dams. As a result dam failure is less a threat now than 5–6 years ago—especially in the East Bay. The job isn't finished, but it is well under way.

The State Seismic Safety Commission and various environmental and consumer groups are helping to assure that the siting and construction of new dams (e.g., Auburn and Warm Springs) take into account seismic hazards.

Also in 1972 the Legislature passed a bill mandating the preparation of inundation maps by dam owners. Local governments must then prepare evacuation plans based on the maps. Compliance has been slow, largely because the State hasn't helped with the cost .

Seismic Safety Elements

Legislation passed in 1971 mandated the preparation of these "elements" as part of a jurisdiction's general plan. There are no provisions for enforcement of the requirement or any formal way to review the adequacy of what is prepared. Consequently a state survey in January, 1979 indicated that seven counties and 52 cities still had not completed an element. Seventeen of these jurisdictions are in the Bay Area. Furthermore many of the elements do not fulfill the Legislature's intent. Even in cases where a technically sound analysis of the seismic issues has been done, there is often no clear commitment to action on the part of the local government. A recent ABAG study of local hazard regulations concluded:

> ***"The policies in most elements are impossible to evaluate by themselves. If they are enforced stringently, proposed development would be greatly restricted. If not, they would not affect development (at all)."***
>
> ***San Francisco Bay Region–A Review of Local Regulations Related to Geologic and Hydrologic Hazards, Constraints and Resources,* March 1977, p. 2.**

"...dam failure is less a threat now than 5-6 years ago—especially in the East Bay." The San Pablo Reservoir dam is shown here being improved.

ABAG photo by Ross Turner

[13] The map on page 14 shows major fault zones in the Bay Area.

Figure 2

quist-Priolo Special Studies Zones

This map illustrates the major fault zones in the Bay Area that have been declared "active" by the State Geologist as of December 1979. The faults are grouped into five major fault "systems."

1. San Gregorio and related faults
2. San Andreas and related faults
3. Hayward and related faults
4. Calaveras and related faults
5. Antioch and related faults

Uniform Building Code (UBC)

In 1961 the earthquake provisions of UBC were moved from an "appendix" to the main body of the code and made mandatory. The problem is that enforcement of the UBC by state and local governments is spotty at best. Some local government building officials have gone so far as to request that the state enforce the code more strictly, only to be turned down by state officials. Also most local governments have not adopted Vol. IV of the UBC, which deals specifically with the problem of existing hazardous buildings.

Local Government Actions

Local government responses to earthquake hazards vary greatly both statewide and regionally. Generally seismic safety is a low priority issue (even before Proposition 13) and few local governments have additional codes or ordinances dealing specifically with earthquake hazards. The clear exceptions are the cities of Santa Rosa, Los Angeles and Long Beach. (See Chart 5).

Santa Rosa has special design requirements and an active program to eliminate dangerous old buildings. Los Angeles has long been a leader in seismic safety legislation. A parapet ordinance, enacted in 1949 resulted in the inspection and repair of dangerous appendages on nearly 25,000 buildings. Currently the city is conducting a survey to identify all existing hazardous buildings and a proposed ordinance requiring their repair is being considered by the city council in early 1979. The Long Beach program was begun in 1959, but code enforcement was suspended until 1965 when a State Supreme Court decision strengthened the legal authority of a city to condemn earthquake hazardous buildings. The current program (passed in 1978) applies only to pre-1933 buildings, dividing them into three grades. The most hazardous (Grade 1) must be repaired immediately. Owners of Grades II and III buildings have 3 to 10 years respectively to complete the repairs.

Many Bay Area jurisdictions have regulations and policies regarding land use hazards. Hillside and slope instability are considered to be the most significant problem (40% have slope/density zoning and 50% require studies prior to development; 80% have grading ordinances) with earthquake hazards ranked as the second largest concern. Very few governments though have given any thought to a plan or process for recovery and reconstruction after an earthquake. Lack of such a plan is largely to blame for Anchorage, Alaska's misguided redevelopment after its 1964 quake.

There is great variety in the content of the regulations, for example:

- Regulations in dam inundation areas range from a ban on development to no restrictions at all.
- Various types of development controls apply to hillside areas. The conditions necessary in order for special controls to apply may be a specific elevation, a percent slope, or a slope stability risk zone. The controls include bans on development, requirements for soils and geologic investigations, lower density zoning and cluster zoning.
- Regulations on Bay mud and other soils with known bearing material problems range from doing nothing to attempts to limit development through indirect purchase of property.
- One of the toughest building regulations in the state is in Marin County. The ordinance requires that information be provided new home or property buyers outlining the stability of the soil and the likelihood of slides in times of very heavy rains.
- In Los Angeles, a city ordinance prohibits building on property that exceeds a 45-degree slope; requires that buildings be set back 15 feet from the top and bottom of the slope; calls for trenches or terraces to curb the flow of runoff water; and sets down an approved list of plants intended to secure topsoil and dissipate potential flooding.
- About half of the jurisdictions responding to an ABAG survey require geotechnical studies for both minor and major subdivisions in Alquist Priolo special study zones; 11 require studies even for a single residence.

  Findings from ABAG's 1977 survey of local hazard regulations relating to earthquake hazards are summarized in Chart 6 on page 17.

While there has been some progress, many of the shortcomings noted by the Joint Committee still apply today.

What Three Cities Are Doing About Hazardous Buildings

Chart 5

The Long Beach program was begun in 1959 with the building code written by former Building Chief Ed O'Connor. The enforcement of this code was suspended until 1965 when a Supreme Court decision strengthened the legal authority of a city to condemn earthquake hazardous buildings in the case of the **City of Bakersfield v. Milton Miller, L.A. 28224.**

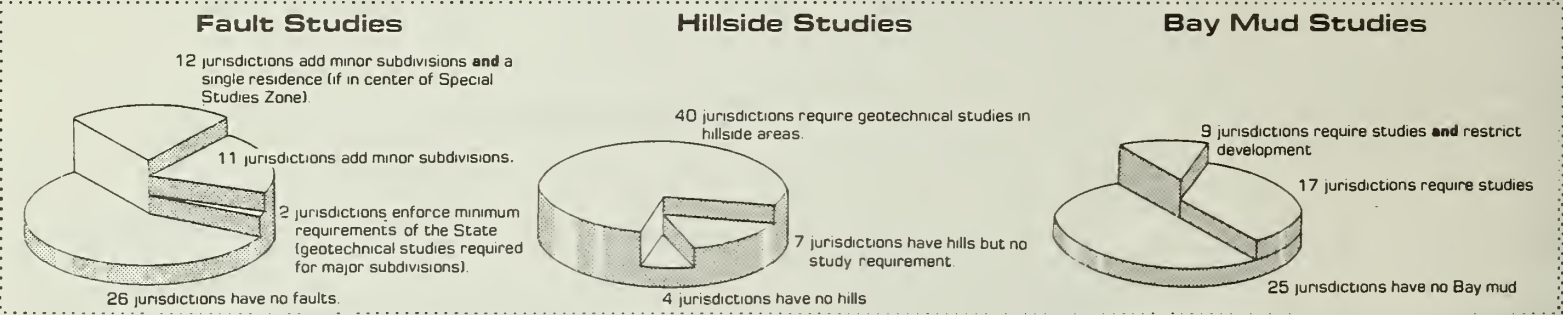
In 1971, "Subdividion 80" went into effect. This established performance standards based on an "importance factor" developed from the Wiggins' "Balanced Risk" concept. This was amended, effective January 1977, by Ordinance 5276 which established a "hazard index" for the preliminary rating of buildings. The buildings would then be graded. Grade I consists of the most hazardous buildings, approximately 10% of those on the index; Grade II, high hazard, approximately 30%; and Grade III, intermediate hazard, the remaining 60%. These grades determine when the building must be repaired. The grading was to be finished by January 1, 1978. Grade I buildings must be immediately repaired, Grade II buildings will be notified to begin repair by January 1981 (3 years after grading established), and Grade III will be notified by January 1988 (10 years after grading). This program is limited to pre-1933 buildings, since that is when the first codes with lateral force requirements were enacted. The current code requirements are essentially the same as the 1970 UBC. Individual inspection is being carried out by the Building and Safety Department to rate and grade hazardous buildings, once their age is determined from existing records. Buildings over three stories must be graded by an architect or engineer hired by the owner. Eugene Zeller is the current Superintendent of Building and Safety, and Marvin Hopwell is the principal civil engineer involved in the abatement program.

The City of Los Angeles program is still in its initial stages. The proposed ordinance, Division 68, **Earthquake Hazard Reduction in Existing Buildings,** is still in a preliminary draft form. The Earthquake Safety Division, Department of Building and Safety, has just completed a survey of hazardous buildings. Their method was to select a census tract, identify pre-1934 buildings from their parapet files and maps, then field inspect them to prepare a catalog of hazardous buildings. The buildings in this catalog were related by use to determine the priority for notification of repairs. Essential facilities have top priority. The rest will be divided into three classifications according to the number of people using the structure. An abatement ordinance is being considered which would require the owner to submit plans and obtain permits for repairs within one year after notification, begin with 180 days of the issuance of the permit and finish not later than three years after notification. Los Angeles would use their own building code for these required repairs.

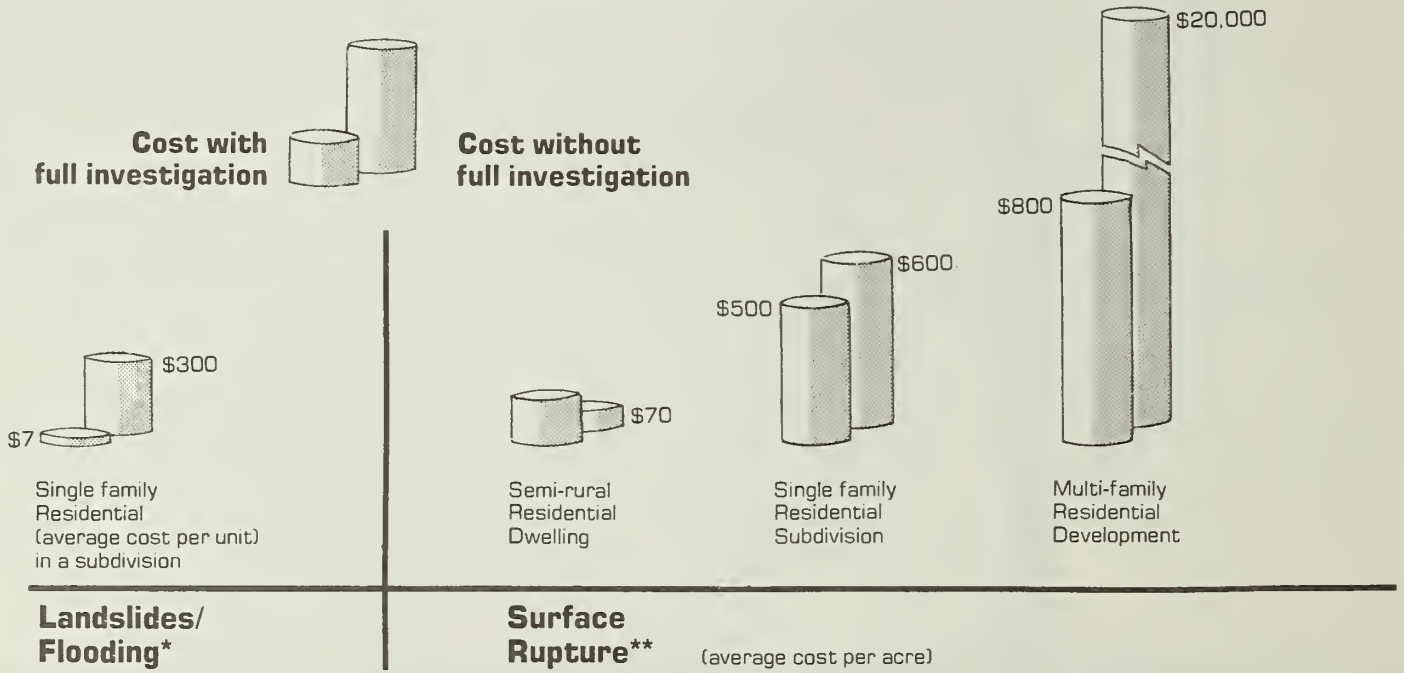
The Santa Rosa Resolution No. 9820, passed in October of 1971, affects buildings built before December 31, 1957, except public schools and one and two family dwellings. Buildings must meet the 1955 UBC requirements upon preliminary inspection, which will be conducted in order of exposure to risk. If the building fails this test, the owner must pay for a thorough investigation by a structural engineer. Depending upon the results of this investigation, the building may continue to be used for 5 years, 1 year, or 90 days from the date of notification. This program is apparently working fairly well, and has had the effect of spurring the redevelopment of the downtown area.

Local Regulations Related to Earthquake Hazards in the Bay Area

In early 1977, ABAG surveyed all of the cities and counties in the Bay Area about local regulations related to geologic and hydrologic concerns. Fifty percent (51 of 101) of the jurisdictions responded. This chart summarizes the survey findings.



Do such studies really save money? Experience in Los Angles and the Santa Clara Valley suggests that investigations can indeed save substantial money in two areas—landslide/flooding investigations for single family residential units and surface rupture studies for multi-family residential structures.



*Based on results of implementing Los Angeles grading ordinance.
**Quantitative Land—Capability Analysis, USGS Professional Paper 945, 1979 (cost figures for surface rupture on Calaveras Fault).

Figure 3

Maximum Earthquake Intensity

This map indicates the maximum earthquake intensity that can be expected to occur at any location in the Bay Area. To produce this map the maximum magnitude earthquake likely to occur on each fault was identified and related in a computer model to distances from the fault and geologic materials. The composite map for all faults was then constructed always using the maximum intensity found to occur at each location.

The map uses the San Francisco Intensity Scale (See Chart 1, page 4 for an explanation of magnitude and intensity).

A—Very Violent

B—Violent

C—Very Strong

D—Strong

E—Weak

Source: ABAG, *Earthquake Intensity and Expected Cost in the San Francisco Bay Area*, February 1978.

Conclusion—Where Are We?

While there has been some progress, many of the shortcomings noted by the Joint Committee still apply today.

> ***"Past performance in seismic safety has clearly been inadequate. Estimates vary widely, but California has perhaps more than 100,000 unreinforced brick or hollow-tile buildings, most of them built before 1933. These buildings are prime earthquake hazards, most of them not having been specifically designed and built to withstand seismic forces. Further, recent earthquakes show that many other types of buildings fall substantially short of providing adequate seismic safety. Some modern buildings are hazardous, as demonstrated by the damage that Los Angeles County's brand new Olive View Hospital sustained in the San Fernando earthquake of 1971. Furthermore, we have continued to . . . erect high-rise structures under conditions that leave authorities fearing for the fate of occupants should an earthquake be followed by fire. Thus, not only has past performance fallen short of meeting the need for earthquake safety but present performance is still clearly unsatisfactory in many respects.***
>
> ***Why has past performance been inadequate? The answer, basically, is that we have failed to implement what is already known about earthquake safety. The familiar economic pressures to build now and hope for the best are part of the explanation. Unawareness, wishful thinking, and preoccupation with day-to-day problems are also responsible. California's policy leaders, in other words, need to be much more concerned with the State's seismicity and the need for earthquake safety."***
>
> *Final Report of the Joint Committee on Seismic Safety, January , 1974.*

> ***"The net result of this general abdication of responsibility (by both public and private sector) is that the state's potential for death, injury and property destruction in a major earthquake is increasing almost geometrically." (emphasis added).***
>
> **John Fried, *Life Along the San Andreas* , (1973).**

It's time to take a closer look at why more isn't being done.

"...the state's potential for death, injury and property destruction in a major earthquake is increasing almost geometrically."

Photo courtesy of Hall, U.S. Geological Survey

WHY ISN'T MORE BEING DONE?

"There's a hell of a lot that we could be doing that we're not."

Karl Steinbrugge, quoted in Time, *Sept. 1, 1975, p. 40.*

No level of government has performed well with regard to seismic safety.

The Federal goverment persists with disaster relief programs which provide few incentives for preventive actions. The state passes laws mandating certain actions by local government, but rarely provides either funding or enforcement of those laws. Few local governments have programs for identifying and reducing earthquake hazards. Enforcement of building codes and grading ordinances is often lax.

Most experts, hoarse from years of exhortation, believe California won't get its act together until a really big quake devastates an urban area.[14] Why not? The answer, a curious blend of economics, politics, and social psychology, lies in two major factors:

1—the lack of a political constituency;

2—the costs (actual and perceived) of reducing hazards.

Why is Earthquake Hazard Reduction Always on the "Back Burner"?

- ***There's so much uncertainty about where and when the next big quake will strike.***
- ***The average citizen shows little concern about earthquake hazards.***
- ***Earthquakes are "good press," but earthquake hazards are generally "bad press."***
- ***The high cost of reducing earthquake hazards is apparent, yet the cost of NOT reducing hazards is less obvious.***
- ***Liability laws are unclear and they may in fact be a disincentive to reducing earthquake hazards.***

[14]Most of California's seismic safety legislation has come in the wake of specific earthquakes.

The Issue with No Constituency

Three interrelated reasons account for the lack of popular interest and support for seismic safety.

Uncertainty About Where and When

Although few dispute the inevitability of a great earthquake, even fewer will venture a guess as to specifically when and where it will hit. This uncertainty makes it incredibly hard for seismic safety to vie with seemingly more pressing concerns for state and local funds. It makes even relatively modest appropriations or bond issues—for the creation of an adequate emergency operating center, or enforcement of a parapet ordinance—difficult to achieve. This uncertainty is a fundamental reason why more isn't being done. It also goes a long way toward explaining the other causes discussed below.

Public Apathy

The public, like its leaders, has shown little tangible concern about earthquake dangers.

- As of 1975 less than 5% of the State's homeowners had earthquake insurance.
- In a 1972 survey of over 500 San Francisco residents about earthquakes, 78% refused to be surveyed.
- Seismic safety has rarely, if ever, been a visible issue in any election campaign or initiative.

Public indifference to earthquake hazards is not irrational from an individual's point of view. The probability of any individual Californian being hurt in an earthquake is quite low. He or she is much more likely to die on the Bayshore freeway. However, the collective odds of **thousands** of Californians being killed in a great earthquake between now and the year 2000 are very high.

> ***"What is rational from an individual's point of view may not be rational from society's point of view. Granted citizens are indifferent (to seismic safety), but this is no excuse why government should be."***
>
> ***Professor Arnold Meltsner, Graduate School of Public Policy, Berkeley.***

There are signs that this indifference is giving way to concern. Two recent surveys[15] have indicated that many people feel that government and the media are not giving them enough information about earthquake safety. Furthermore, a recent article in *New West* magazine indicated a growing consumer awareness of these kinds of issues. The article reported citizen outrage at local and state officials who came in like heroes handing out relief checks after the 1978 L.A. mudslides ruined a lot of homes. The citizens asked why government allowed developers to build and sell homes in such hazardous locations in the first place. As L.A. County Supervisor Baxter Ward put it: "The residents of the county are appalled that permits are issued on hillside properties that are unsafe (in severe rainstorms). The public thinks, justifiably or not, that there is some implied guarantee that government knows what it is doing."

Media Apathy

The media have a hard time covering long-term issues like earthquake safety. Coverage inevitably focuses on the horrors of a specific quake somewhere in the world.

> ***"Experience reveals that the public most readily responds to information presented through the mass media on a routine and frequent basis (e.g., once a week prime time news). In this way the media can become an important part of preparedness planning at its earliest stages."***
>
> **Ron Davis, *Coping With Disasters at the Local Level*, Washington, D.C.: International Center for Emergency Preparedness, 1978, p. 23.**

This has not happened in California.

The result of this uncertainty and apathy is that the political battles over seismic safety pit a few public officials and the earthquake professionals (engineers, seismologists, emergency services, etc.) against the forces of inertia and numerous special interest groups. For example, the realtors and developers usually oppose seismic safety legislation because it may mean more regulation or higher costs.

[15] *Study of Community Response to the Palmdale Bulge*, Professor Ralph Turner, 1978 and *San Francisco Examiner Survey*, 1977.

The Costs of Reducing Earthquake Hazards

Until there develops more public demand for earthquake safety, the cost (perceived and actual) factor will be the biggest barrier to greater reduction of hazards. More specifically, the major problem is the huge expense of repairing or replacing existing hazardous buildings in urban areas.

San Francisco Building Inspector Al Goldberg believes that it would cost $2-3 billion to replace or repair the 11,000 hazardous buildings in San Francisco excluding relocation costs. Statewide the figure could run to $20 billion.

Earthquake safety measures for private structures would no doubt increase costs to owners and developers. Repairs to public facilities would probably require new taxes or bond issues, which even before Proposition 13 were passing infrequently.

The costs of reducing hazards are clearly perceived. Less well understood, but equally real, are the costs of **not** reducing them. The lowest benefit/cost ratios are associated with complete repair or replacement of hazardous buildings. Partial measures such as parapet removal or reducing occupancy are more cost effective.

Of course the net value of such savings depends on the time elapsed between spending (repair) and saving (the earthquake). Generally studies and experience indicate the wisdom of such prevention. For example, the 1971 San Fernando earthquake confirmed the value of the Los Angeles parapet ordinance. Parapets didn't fall and in some cases the structural improvements made to connect the parapets saved whole walls.

And finally, it should be remembered that large repair and replacement programs would generate many new jobs.

"Given a continuation of present conditions, it is estimated that losses due to earthquake shaking will total $21 billion (in 1970 dollars) in California between 1970 and 2000. Most of the damage and loss of life will occur in zones of known high seismic activity; structures that do not comply with the provisions of the Field and Riley Acts, passed in 1933, will be especially vulnerable. If the present-day techniques for reducing losses from earthquake shaking were applied to the fullest degree, life loss could be reduced by up to 90 percent, and the total dollar value of losses could be reduced by as much as 50 percent. Total costs for performing the loss-reduction work would be about 10 percent of the total projected loss, which with 50 percent effectiveness provides a benefit: cost ratio of 5:1."
Urban Geology: Master Plan for California, California Division of Mines and Geology (1973).

"The benefit/cost ratio for structural modification is 5 to 1."
Munroe and Carew, Economic Analysis of Adjustments to Earthquakes (1974).

"For most geologic hazards the loss amount is generally reduced well over 90% when construction codes are enforced."
California Geology, Vol. 30 (1977).

Liability: a New Barrier

At the 1976 ABAG General Assembly several member governments raised the idea that worry over liability may be a new barrier to reducing earthquake hazards. Citing recent court cases and the general trend in the law toward ever-greater government liability they suggested that ABAG staff try to determine if this was indeed the case. Using funds from the National Science Foundation, a year-long study of local government's potential liability for earthquake losses was conducted by ABAG and a nationally prestigious panel of legal and earthquake experts.

The study findings confirmed some of the fears voiced by ABAG members. There are two problems with the current law which act as barriers to hazard reduction.

The Problem of Uncertainty

In a survey of nearly 400 local officials in four earthquake-prone states (California, Utah, Washington, and Alaska), 96% felt that liability laws were too uncertain and unpredictable to be useful guides to local decisions about earthquake hazards.

Others have documented this problem too. A recent report by the National League of Cities contended that "there is a need to clarify the scope of municipal liability—cities cannot operate in an environment devoid of guidelines."

The result of this uncertainty is to reduce the impact of the law on local government behavior. Clearly if local governments do not understand the law or feel that it is predictable, then liability considerations will not be a significant factor in their decisions. What this means is that laws designed to promote safety and reduce negligence don't even have a chance to work.

But the problems with the present law go even deeper. In several ways the present law, even if properly understood, **discourages** governments from reducing hazards (hazards of all sorts—not just earthquakes).

The Problem of Disincentives

1.—**"THE MORE YOU KNOW" PROBLEM**—One feature of California liability law is that it imposes certain obligations on government once it has "actual knowledge" of a hazardous situation. While it makes sense not to hold government liable for a hazard of which it is unaware, the unintended incentive of this rule is to discourage local governments from discovering hazards through inspection programs or building surveys. The effect of this is clearly evident in this excerpt from a response by San Diego Mayor Pete Wilson to a request by the American Institute of Architects (AIA) for cooperation in a proposed study of the seismic safety of private buildings in that city.

> "I will be happy to provide official letters to building owners enlisting their cooperation; however, it is not considered appropriate at this time to deputize the (AIA) evaluators as (city) building inspectors since such status may impose an obligation to require correction of buildings determined to be unsafe."

2.—**MANDATORY DUTY RULES**—The content and language of local ordinances can be legally relevant in liability cases. Local enactments may impose obligatory duties, for which non-compliance could result in liability. This fact gives local governments a considerable incentive to avoid adopting such ordinances or to word them so as to avoid creating a mandatory duty. In a recent Washington case the state supreme court held Seattle liable for failure to enforce the building code because of a wording technicality in the code. Needless to say the city quickly changed the language, not only in that ordinance, but in many others also—reducing its legal responsibilities for reducing hazards.

3.—**AFFIRMATIVE DUTY RULES**—If a jurisdiction voluntarily chooses to provide a certain service, it may increase its potential liability if it performs that service negligently or—after having caused people to **rely** on the service—fails to perform at all. This type of disincentive related to medical treatment in emergencies is what made necessary the enactment of the so-called "good-Samaritan" statutes protecting doctors and nurses. Examples of this are—provision of lifeguards on beaches, bike lanes programs, and most relevant, building inspections. In a case decided by the Alaska Supreme Court in 1976, governments were declared **not** liable for failing to conduct building inspections but **were** liable for failing to follow up on inspection findings. This ruling resulted in a severe reduction in inspection programs of state and local governments.

Such disincentives may be why the Commission on Government Reform, chaired by A. Alan Post, found that "there is an increasing conservatism in the provision of many needed governmental services because of their liability potential."

All of these disincentives inhibit a major purpose of the law, namely to deter negligence, prevent accidents, and promote safety. Furthermore, as awareness of liability issues increases (which it is) the negative consequences of these disincentives will also become greater. More and more local governments will pull back because they feel that increasing safety goes hand in hand with increasing potential liability. Governments should not be penalized for taking steps to discover and eliminate earthquake hazards. Changes are needed so that a local government doesn't have to choose **between** protecting its citizens as taxpayers **or** protecting them as potential earthquake victims.

ABAG-sponsored legislation to correct this situation was introduced in 1979 by Assemblyman John Knox (AB 785). Several features of this bill were amended into SB 555, sponsored by the Seismic Safety Commission, and enacted into law in 1979. The new law substantially improved local government immunity, and, together with SB 445, also enacted in 1979, should act as an incentive to hazardous building reconstruction.

[16]For more on this issue see *"Will Local Governments Be Liable for Earthquake Losses?"*, by Terry Margerum, ABAG, January, 1979.

REDUCING THE DANGERS: WHAT LOCAL GOVERNMENTS CAN DO

Most Bay Area citizens know that they live in earthquake country, but don't realize that one person in fifty could be killed if a great quake struck during a week-day noon hour or rush hour. Moreover, an individual's chances of being killed are nearly twice as high here as in the Los Angeles area.

The job of reducing the Bay Area's risks to a more acceptable level will not be easy or cheap. Nor is it impossible—if viewed over a span of 10-20 years—a grace period which, hopefully, tectonic geology will allow.

The 1975-77 drought demonstrated that Bay Area citizens and governments can respond effectively to a crisis. The problem posed by earthquake hazards is less acute, but far more grave.

Section Four describes specific steps which local government can take to reduce earthquake hazards. While the emphasis is on local government, needed State and Federal actions are noted where appropriate.

Why L.A. is Safer

Los Angeles is safer because it has: fewer old buildings per capita, fewer high rises, a less concentrated downtown, a hazardous building survey program, a more modern and efficient emergency operating center, and a parapet ordinance which has been enforced for 20 years.

Five Essentials For A Local Government Earthquake Program Safety

1. ***A comprehensive program to reduce hazards in existing buildings.***
2. ***Regulations to ensure that new buildings are earthquake resistant.***
3. ***Constraints on land use based on probable effects of earthquakes.***
4. ***A solid emergency and disaster response capability.***
5. ***A public information and education program.***

The first steps in any program to reduce earthquake hazards should be based on three primary criteria: life-safety, cost, and potential liability.

Life Safety

Obviously local governments want their first actions to be those which would save the most lives. The major determinants are average occupancy and daily use. Average daily use takes into account how often and for how long a structure is occupied. Its importance can be seen by comparing a basketball auditorium (which holds 10,000 people but is used only 20 times a year for 3 hours at a stretch) with an apartment building which holds 100 persons year-round 16-24 hours a day. In terms of reducing human exposure to risk, fixing up the apartment building clearly produces a greater benefit—and at a much lower cost than the larger structure.

Other examples of actions which might save many lives are reinforcing a dam or prohibiting new construction in hazardous areas.

Cost

Some of the steps necessary to reduce hazards cost a lot of money, but many do not. Furthermore, the cost of inaction may be higher—in both human and economic terms. That is why it is essential to view the cost of mitigating earthquake hazards over the long term, i.e., 15—20 years. This not only allows capital costs to be spread out but, since a major quake in that time period is very probable, also makes it easier to factor in the costs of inaction. For example, $300,000 spent now to upgrade the County Courthouse may reduce earthquake damages by 3 or 4 times that amount.

Potential Liability

Legal experts agree that in certain situations local governments could be held liable for injuries and deaths caused by their negligence or failure to abate known or suspected hazards. Several factors affect the likelihood of liability.

- **Public vs private structures**—local government has an obligation to eliminate "dangerous conditions of public property." If the injuries occur in a public building (e.g., a county hospital or a city hall) the likelihood of liability is much greater than for private property. Public right-of-ways (e.g., sidewalks) made dangerous by falling private property (e.g., cornice or parapet might also be a source of liability for local government.

- **Dependent vs involuntary populations**—to the extent that the people injured are "involuntarily" present (e.g., jail, school, court, hospital) the chances of liability are greater.

- **Cost**—if the hazard which caused the injury could have been eliminated easily (i.e., at relatively low cost), the court would be more likely to find liability. This is an important distinction, because it illustrates the importance of the "reasonableness" criterion in a court decision.

While it may not be financially possible to replace the county hospital or require complete abatement of dangerous private structures, a court is unlikely to consider parapet removal or land use controls to be financially prohibitive.

Continuing the example of a hazardous county hospital, which must be used and can't be repaired or replaced at low cost; resonable course of action might be to authorize a bond issue or establish a long-term financial plan for eliminating the hazard. An unreasonable course of action would be to ignore the problem and do nothing.*

Using these three criteria local governments can select a hazard reduction program which best fits their situation. The balance of this section of the report describes some possible components of such a program.

*See ABAG's Earthquake Liability Study publications (listed on page 36) for more information.

A
Ideas for a Comprehensive Mitigation Program

A primary goal of any mitigation program should be to reduce hazards in existing buildings. Collapsing structures will be the major cause of death and injury in a moderate or great earthquake (41 of the 58 deaths in San Fernando in 1971 resulted from the collapse of a Veterans Hospital building). The amount of risk is determined primarily by the age and type of structure, the commercial-residential mix, the proportion of residents who live in single-family houses and the day and night occupancy figures. For these factors *higher risk* is associated with:

- higher occupancy, older buildings of unreinforced masonry construction (usually pre-1934 construction);
- high percentage of residents in apartment buildings;
- high daytime occupancy of commercial buildings.

In practical terms a building is earthquake hazardous if it has any of the following characteristics:

1) Was contructed prior to the adoption and enforcement of local codes requiring earthquake resistant design of buildings;

2) Is constructed of unreinforced masonry; and

3) Exhibits any one of the following characteristics:

   a. exterior parapets and ornamentation that may fall on passers-by;

   b. exterior walls that are not anchored to the floors, roof, or foundation;

   c. sheathing on roof or floors that is not capable of withstanding lateral loads;

   d. large openings in walls that may cause damage due to torsional forces;

   e. lacks an effective system to resist lateral forces.

Most such hazardous buildings in California are privately-owned and any comprehensive program for their repair or replacement will require State or Federal financial assistance and the cooperation of private financial institutions. However, there are steps local governments can take to reduce significantly the danger to life posed by such structures.

A Checklist for Reducing Earthquake Hazards

1. Inventory hazardous buildings

2. Adopt and enforce latest Building Code

3. Improve inspection practices

4. Upgrade building department staff

5. Post dangerous buildings

6. Reduce occupancy in hazardous structures

7. Offer tax incentives

1. Inventory

The first step in a mitigation program is an inventory of hazardous buildings. Buildings should be identified by age, value, ownership and socio-economic type of occupancy. Depending on the size and age of the jurisdiction this could be a minor or herculean task. Its feasibility is demonstrated, however, by the fact that both Los Angeles City and Los Angeles County have done such surveys. Early figures from the city's survey (completed in early 1979) indicate that there are about 9,000 hazardous buildings, whereas the County expects to find fewer than 500. By comparison, Al Goldberg, San Francisco's Building Inspector, estimates that S.F. has between 10,000 and 11,000 earthquake hazardous buildings.

The cost of doing such an inventory is not prohibitive, especially in smaller, younger jurisdictions. The City of Los Angeles estimates that their cost was between $300,000 and $400,000 over 2 years.

If resources aren't available to do a comprehensive survey the criteria above suggest that at the very least a thorough survey of the structural integrity of the jurisdiction's own structures and critical facilities (hospitals, police and fire stations, community facilities) should be done. Also advisable is a review of public right-of-ways which might be endangered by falling parapets or cornices. Another priority would be any high-occupancy apartment buildings which are suspect.

There is much information available about conducting surveys. Some general sources are the Earthquake Engineering Research Institute and the California Chapter of the American Institute of Architects. The building departments in Santa Rosa and the City of Los Angeles also could be helpful. There are numerous professional groups as well. An excellent manual on the subject is available through NTIS[17]—*Hazards Evaluation of Existing Buildings* by Culver, Lew, Hart and Pinkham (1975).

2. Building Codes

Adoption and enforcement of the most recent Uniform Building Code (UBC) with its "Dangerous Building" section (Vol. IV) is extremely important—especially enforcement, which is often inadequate. There may be a liability problem here too. Although the California Tort Claims Act provides immunity for "failure to enforce any law," recent court decisions have eroded that immunity and made the outcome of cases dependent on specific facts and judgments about whether "negligence" was involved, whether government ignored "duty", and finally whether the inspection/enforcement was a "discretionary" or "operational" function. Only discretionary acts are immune.

[17]National Technical Information Service.

Public vs. Private Hazards

There are four good reasons why local government's early mitigation should focus on its own property.

1. There is a greater moral responsiblity to make sure public structures are safe.

2. A clear commitment to "get its own house in order" can be a powerful example to the private sector, both directly and indirectly (through citizen and media pressure).

3. The cost of inventorying its own property for hazards will be a lot more reasonable than trying to tackle all hazardous structures.

4. With the greater responsibility also comes greater potential liablity, which cannot be ignored.

3. Inspection Practices

Some jurisdictions require thorough inspections of property when there is a change of ownership, change to higher occupancy, or proposed modification or rehabilitation. At this time the structure must be brought up to current code, including seismic requirements.

For some older buildings this is financially infeasible and can inhibit redevelopment efforts. Some jursidictions like Seattle avoid this by requiring that the building be made earthquake resistant enough to prevent collapse, but do not insist on full compliance with the *latest* code. Some California jurisdictions would like to do the same but haven't due to fear of liability for not fully enforcing their codes. Legislation (SB 445) supported by ABAG and the State Seismic Safety Commission removed the reason for this worry by allowing lower standards for rehabilitation of old hazardous buildings.

4. Upgrading Staff

Several experts, when asked what should local governments be doing to reduce hazards mentioned that the technical competence of local building departments is extremely variable, and that many cities and counties should upgrade their staffs' abilities through tougher job requirements, hiring practices, and on-the-job training.

Several city managers who were consulted agreed. They saw vast differences in what their building department could do after they began, for example, requiring structural engineering degrees for inspection jobs.

5. Posting of Oangerous Buildings

Often called the "cigarette pack" approach, this alternative should be considered for hazardous buildings which for one reason or another (lack of money, historical preservation, etc.) cannot be made safe. This approach makes people aware of dangers to which they are exposed. Owners of commercial property will probably oppose such an ordinance, because it puts dangerous buildings at a competitive disadvantage in the market place. The outcome of this is hard to predict. It could lead to abandonment of certain buildings, conversion to lower occupancy uses (e.g., a warehouse) or provide powerful incentives to mitigate the hazard. Another version of the posting option, which allows property owners to avoid the stigma of being posted, would be to advise them that unless repaired within a given period, say, 6 months, the building will be posted.

A posting ordinance was seriously considered by the L.A. City Council in 1977.

6. Mandatory Reduction in Occupancy

This could be an alternative or supplement to posting. The occupancy of a hazardous structure could be reduced to lower levels over specific periods of time.

7. Tax Incentives

Local government could employ tax incentives to encourage owners to make the changes necessary to make their buildings earthquake-resistant. This could be done by property tax exemptions. Exemptions could be combined with an abatement ordinance for example, delaying for some time any tax on the increased value of the property due to the repairs. Local governments could enact an earthquake safety tax on use of hotels, theatres and other places of public assembly. The money raised could be used to make such structures earthquake-resistant.

Needed State and Federal Changes

Federal

- Make more Federal dollars available for prevention, e.g., through matching grants and low interest loans, for repair of hazardous buildings. Allow local government to administer the program so it can be coordinated with other redevelopment efforts.
- Revise Federal regulations to allow use of urban renewal and relocation funds to abate earthquake hazards in existing buildings.
- Revise Federal income tax laws to prohibit reuse of hazardous buildings for tax shelter investments, unless the hazards are mitigated.
- Prohibit Federally financed loans for hazardous buildings.
- Future public works and revenue sharing bills should include abatement of hazardous structures as a desirable factor in evaluating applications.
- Authorize the Corps of Engineers to help local governments mitigate imminent hazards, first of all in high-occupancy publicly-owned structures.

State

- Change state regulations on relocation and urban renewal funds as with Federal regulations.
- Change income tax laws on tax shelter investments as with Federal regulations.
- Legislate earthquake safety bond issues to be used as source of money for low interest loans to repair hazardous buildings.
- Provide building inspection assistance to small jurisdictions unable to afford full-time structural engineers.
- Enforce State laws and regulations on building code adoption and enforcement.
- Establish "earthquake life-safety" building standards for use in rehabilitating old buildings. These standards will be less rigorous than the most recent codes which often make it economically infeasible to rehabilitate older buildings.

B
Special Problems

1. Parapets and Appendages

Parapets and such appendages are the most common earthquake hazards in California. A great increase in the safety of streets and sidewalks would result from effectively enforced parapet ordinances.

Few jurisdictions have such ordinances and even fewer enforce them. San Francisco's ordinance was adopted in 1969. An estimate made in 1978 indicated that fewer than 150 of the more than 10,000 suspected dangerous parapets in San Francisco have been repaired. Estimates from Los Angeles, San Francisco and two private firms place the cost at $60-75 per lineal foot of frontage on a street, alley, or sidewalk. Since the cost is a function of the amount of frontage, the expense of repairing a 12-unit structure will not be twice that of a 6 unit structure, other things being equal. In other words, the cost per apartment unit can be much less in larger buildings.

As noted earlier, parapets pose serious potential liability for local government. The resource spent in the adoption and enforcement of a parapet ordinance would be money well-used both in terms of public safety and the public purse. The long-enforced parapet ordinances in L.A. (City and County) saved many lives and dollars in the 1971 earthquake.

2. High Rises

Jurisdictions with medium- and high-rise developments should consider:

- Adopting an ordinance requiring the preparation of internal emergency response plans for medium- and high-rise buildings.
- Amending building and zoning ordinances pertaining to medium- and high-rise developments to provide for earthquake safety considerations including pedestrian safety, access for emergency vehicles, and evacuation assembly areas.

"Parapets and such appendages are the most common earthquake hazards in California."

ABAG photo by Pat Yoshitsu

3. Private Hazardous Buildings: A Joint Effort is Needed.

Of course, most earthquake-hazardous buildings in the Bay Area are privately owned. Complete mitigation, as opposed to partial steps, like parapet removal or posting of these hazards, is beyond the financial capacity of most local governments.[18]

Nor does it seem reasonable to place the entire burden on the owner or (more probably) the residents through increased rents. Although they are the direct beneficiaries, it may be unfair to have them collect the tab for years of neglect.

The Federal and State governments should assist those local governments that wish to institute comprehensive hazard abatement programs.

[18] A few cities have programs, for example, Long Beach and Santa Rosa. In Los Angeles, an ordinance was proposed to the City Council's Building and Safety Committee in 1979. The ordinance, currently under study, would require the owner of a building found to be hazardous to begin the necessary repair work within one year of notification and complete the correction within three years.

C
Making Sure New Buildings are Earthquake-Resistant

Generally speaking, post World War II buildings have performed adequately in earthquakes—even in quakes as great as that which hit Alaska in 1964 (8.4-8.6 Richter). However, in each recent quake there have been conspicuous exceptions to this general rule.

The Four Seasons, a just completed high-rise apartment building (due to be occupied two weeks later), completely pancaked in Anchorage in 1964. Hundreds would have been killed had the building been occupied.

The Olive View Hospital in San Fernando in 1971 was rendered unsalvageable due to failure of the 1st floor and the elevator towers.

To some extent we must simply live and learn, with each earthquake providing a graphic lesson in what works and what doesn't. Often failures like those above can be blamed on poorly chosen design or construction technique. This cannot be completely avoided.

Other times, however, failure of recently built structures is due to factors which *can* be avoided such as:

- design flaws
- inadequate materials
- poor construction practices
- failure to follow the design, materials and construction techniques called for in the plan
- failure to follow the building codes
- poor choice of building site (it matters less how well-engineered a building is if the land is going to slip into the sea or sink 20 feet due to subsidence). Reports from the minor 1978 Santa Barbara quake described many cases where construction errors or failure to follow code resulted in significant damages to buildings built after 1950.

The cost of making new buildings earthquake resistant is low compared to old hazardous structures. The extra cost of earthquake-resistant construction in new buildings averages between 2 and 5 percent. And over the life of the building—which, in most of California, surely means being hit by at least a moderate quake—this will prove a net saving rather than a higher cost.

What can local governments do to be sure that new buildings, especially those with high occupancies, are built seismically safe?

- prohibit the location of new subdivisions in seismically dangerous areas;
- modify zoning ordinances to reflect the seismic performance standards necessary for safe use of the land;
- require reports on transfer of property to include reference to any existing geologic or seismic information on the site;
- require construction setbacks on all faults.
- as part of the general plan, prepare a Post-Earthquake Recovery and Reconstruction Land Use Plan.

Besides location the key factor is the content and enforcement of existing building codes. Nearly all California local governments use some form of the uniform building code (UBC). The later versions have stricter seismic requirements. (See Chart 10). Some jurisdictions (e.g., San Francisco, Santa Rosa) have tougher requirements. At a minimum local government should:

- Adopt the latest version of the Uniform Building Code.
- Conduct thorough reviews of plans and designs to assure adequacy and compliance.
- Conduct adequate inspections to assure enforcement. This includes unannounced visits to construction sites and close supervision.
- Where appropriate (e.g., near a fault or in poor soils—or for critical/high occupancy structures) establish additional design and study requirements.

The State should require, by law, earthquake-resistant design in all its facilities and in all facilities financed (wholly or in part) with State funds. The Federal government should do likewise.

The State should also provide technical assistance to local governments who need help in review and approval of major new construction projects.

D
Land Use

This goes beyond simple avoidance of known earthquake faults. It requires broader consideration of whether or not the land is, in fact, compatible with a proposed use. In addition to the direct effects of fault movement and ground shaking, there are other constraints on land use that are triggered by earthquakes:

- **landslides**—road construction, landscaping and other development activities can increase the vulnerability of an area to landslides—both generally and those triggered by earthquakes.

- **flooding**—with regard to earthquakes, the problem would result from failure of dams, dikes, or levees.

- **liquifaction, subsidence and settlement**—these "bearing material" problems are accentuated and accelerated by earthquakes and can result in great damage to structures. In the 1964 Alaskan earthquake parts of Anchorage sank 30 feet; a nearby island 38 feet. Locally, bayfill areas are particularly vulnerable.

Most Bay Area jurisdictions are close to a known fault and have at least one of these other problems. Many have much development on alluvial soils. There are chronic landsliding problems in most Bay Area counties. San Francisco, San Mateo and Alameda counties have developed a lot of bayfill property. And so on...The amount of danger associated with these types of land is dependent on their use. A mixture of weak soil with bad structures, as in San Francisco's Tenderloin or some of Berkeley's older hillside areas produces a great potential for loss of life in an earthquake.

Of course, many Bay Area jurisdictions are young developing areas with the opportunity to avoid such mismatches between land and use.

There is much that local government can be doing that is both wise and inexpensive. A comprehensive program would include the following:

- identify and map hazards in order to develop risk zones for the jurisdiction; much data and some technical assistance is available from ABAG, the U.S. Geological Survey (Menlo Park), and the California Division of Mines and Geology;

- integrate seismic considerations into local plans and environmental impact documents;

- adopt and enforce adequate grading ordinances (see Uniform Building Code, Ch. 70);

- make building permits dependent on an assessment of the seismic stability of foundations and critical slopes;

- have a competent soil engineer and engineering geologist review building and grading permits to determine if soils and geologic reports are needed;

Anchorage, Alaska — A Case Study of WHAT NOT TO DO

Anchorage was not intensely developed at the time of the 1964 earthquake. Major changes in the location and configuration of the city could have been made after the quake without severe economic impacts. Public land was available on the city's periphery. A lot of Federal money was available through a variety of programs. However, pressures from the business community thwarted the attempt to rebuild Anchorage on a safer site. Not only were proposals to relocate the central business district defeated, but even such moderate ideas as prohibiting structures within 500 feet of the slide areas were ignored. Consequently, many of the areas most heavily damaged due to landsliding, subsidence and liquifaction in 1964 have been redeveloped more intensely than before. The L Street area, one of the worst hit in 1964, is now occupied by numerous high rise structures, some of which local geologists believe will be split by surface rupture in the next quake. There are plans to redevelop Turnagain Heights, a residential area where more than 75 homes were completely destroyed in 1964.

San Andreas Fault

"...*all* proposals to zone or subdivide land in a seismically hazardous zone should be reviewed."

Photo courtesy of Wallace, U.S. Geological Survey.

Needed State and Federal Changes

State

- The Alquist-Priolo Special Studies Zone Act should be amended to include all geologic hazards, not just faults;

  1) clarify the relative responsibilities of the State geologist and the State Mining and Geology Board;

  2) clarify the collection and assignment of fees;

  3) clarify requirements for review of technical reports in support of developments; and

  4) Provide that *all* proposals to zone or subdivide land in a seismically hazardous zone should be reviewed. Approval should be contingent upon the subsequent geological report and consistency with the seismic safety element.

- Legislation dealing with other geologic hazards, not just faults.

- Property reports now *allowed* prior to the transfer of properties should be made *mandatory* and include resale of vacant properties with non-residential structures. The law should specify that where official city and county information pertaining to the site exists, it must be noted on the residential property report.

- Amend State Code Section 54790 and 56250 so that Local Agency Formation Commissions are required to consider seismic safety factors in their deliberations.

- The Subdivision Map Act should require that any geologic information on a subdivision be recorded in the appropriate city or county offices and on the final and parcel maps. Geologic and soils engineers must certify the final map.

Federal

- Federal loans and grants should not be allowed to finance development in seismically hazardous areas, unless adequate mitigation steps are taken. (The Anchorage experience was a conspicuous failure to implement this type of policy.)

- The Federal government should make sure that its own facilities are developed in a manner consistent with increased seismic safety.

F
Public Information and Education

Awareness of California's proclivity towards earthquakes is fairly high among its citizens. However, that awareness is more fatalistic and less constructive than it could be. For example, a 1977 San Francisco Examiner survey revealed that nearly half the population doesn't know how to take even the most basic safety precautions such as turning off the gas. So easy a task and one that will save lives and property! That so many people could be so dangerously ignorant underlies a failure on the part (in this instance) of government, the media and P.G&E.[20] That same survey also showed that in San Francisco, only 12% knew where the nearest emergency care center was. A T.V. interview found the late Mayor Moscone among the 88% that did not know.

This lack of knowledge can be attributed to several factors including apathy and the failure of such institutions as those noted above. However, it also stems from a fundamental ignorance of the potential consequences of a great earthquake. Most people do not understand the magnitude of the danger. If they were aware of some of the eventualities described in the first part of this report, they would not only know more about what to do and how to cope, **but** they would also be demanding that government focus more attention and resources on reducing earthquake hazards. Earthquake safety is a consumer and political issue of great latent power. As noted earlier, recent research in Southern California indicates that this dormant constituency may be finally awakening.[21]

Once again there are a number of things local government could be doing to heighten "constructive awareness" of earthquake dangers.

Seismic Safety Progress Reports—the jurisdiction could issue periodic reports of the status of the local government's seismic safety and disaster preparedness programs. What are the biggest problems? Old buildings? Lack of emergency communications? High landslide potential? What's being done about these dangers?

Consumer Information—a brochure could be prepared and given to homeowners describing how they should assess the earthquake vulnerability of their house and property. It would describe the advantages and disadvantages of different types of construction (wood frame, stucco, brick, one-story, two-story, split-level, etc.) and tell people how to find out about local geology and topography. It would also explain the cost and benefits of earthquake insurance and help them decide if they need it.

School Curriculum—an earthquake hazards program could be required which explained the dangers and what can be done to reduce hazards around the house and what to do when the earthquake strikes.

Poll the Electorate—the people could be asked a series of questions about the priority of earthquake safety and what they think should be done. This could be done by a professional survey firm or on the local election ballot.

Disclosure—full disclosure of all existing information about geological conditions could be required whenever a property is sold. It could be incorporated in the property report.

There are also things the State can do to help these efforts.

Excellent pamphlets about what to do before, during, and immediately after an earthquake have been developed by USGS and the State Office of Emergency Services—but they have not been widely disseminated enough. A copy could be mailed with the annual State income tax materials.

A statewide referendum on earthquake safety could also raise awareness and give government a better reading of where the public puts seismic safety in its priorities.

[20]Note, however, that new editions of the Telephone Directory do have a survival guide—including important earthquake information—in the introductory pages.

[21]47% of those interviewed think government is not giving them enough information about earthquakes. Professor Ralph Turner, UCLA Study of Community Response to the Palmdale Bulge.

G Resources and References

The references below are "starting points" that will lead to more information about "Reducing Dangers—What Local Governments Can Do."

General Information

- California Seismic Safety Commission (916-322-4917)
- Association of Bay Area Governments (Jeanne Perkins)

Existing Hazardous Buildings

Books
- Survey and Evaluation of Existing Hazardous Building in book titled *Building Practices For Disaster Mitigation,* available from National Bureau of Standards, U.S. Department of Commerce.
- *Natural Hazards Evaluation of Existing Buildings* by Charles G. Culver, available from NTIS.

Programs
- Earthquake Safety Division, City of Los Angeles (Earl Schwartz)
- City of Santa Rosa (Ken Blackman, City Manager)

Sample Ordinances

Parapets
- City of Los Angeles
- City of San Francisco

Special Rehabilitation Codes
- City of Seattle
- Senate Bill 445 (Alquist, 1979)

New Construction and Current Codes

- Compendium of State Codes Related to Seismic Safety, available from California Seismic Safety Commission.
- San Francisco and Los Angeles Building Codes

Land Use

- *Quantitative Land-Capability Analysis* by Laird, R.T. *et. al.,* (Professional Paper 945, 1979) available from the U.S. Geological Survey.
- *Fault Hazard Zones in California,* by Hart, E.W. (Special Publication #42, revised January, 1976) available from the California Division of Mines and Geology.
- *Urban Geology: Master Plan for California,* by Alfors, J.T. *et. al.* (Bulletin 198, 1973) available from the California Division of Mines and Geology.

Disaster/Emergency Preparedness

- State Office of Emergency Preparedness (Roger Pulley)

Liability

- *Legal References on Earthquake Hazards and Local Government Liability* (December, 1978)
- *Will Local Government be Liable For Earthquake Losses?* (January, 1979)
- *Attorney's Guide to Earthquake Liability* (May, 1979)

Liability references available from the Association of Bay Area Governments.

CONCLUSION

Earthquakes of great magnitude in the Bay Area are inevitable. They've occurred over thousands of years and they will happen again. It is not a matter of **IF** but rather **WHEN.** Most experts think a large quake is likely before the year 2000. Many believe a great eartnquake will occur before the end of the century.

Given our present lack of preparedness the consequences of an earthquake of 7.0 magnitude or greater will be truly horrifying. Thousands of people will be killed or injured and the property damage will total in the tens of billions of dollars. Afterwards the finger-pointing and recriminations will create an uproar that will make the recent Three Mile Island incident seem remarkably tame—or in Karl Steinbrugge's words cited earlier:

"Thousands of people killed in a few seconds is going to blow the lid off this country, and it's going to happen."

People will claim that government again let them down, that state and local officials have known for years about California's treacherous inventory of old buildings.

The press will charge that powerful interest groups have lobbied against state and local ordinances that would have reduced hazards, or at least warned of their existence.

Cities and counties will be accused of having passed earthquake safety ordinances but failed to enforce them.

Suits will be filed against both public and private building owners charging that property known to be dangerous was not made safe.

There is some validity to these charges. But the charges are also unfair in light of the average Californian's nonchalance about earthquake dangers.

A recent Field poll found only one citizen in 20 worries very much about earthquakes. More than 60% said they didn't worry at all! These attitudes are also reflected in the fact that less than 5% of the State's homeowners have earthquake insureance.

We are all at fault, so to speak, for the lack of preventive steps. This fact will surely be forgotten after a disastrous earthquake. Blame will be, most probably, focused on those "in authority."

Presently, such a scenario seems inescapable for the Bay Area. It can only be avoided if somehow the political will and financial resources can be found to embark on a long-term (10-20 years) program to reduce the most obvious hazards. This can come about in two ways:

1.—through effective and imaginative public and private leadership a constituency and coalition for change can be created

or;

2.—a disasterous earthquake strikes some other metropolitan area first, demonstrating the immense folly of our present apathy.

The choice seems clear: to build on the leadership shown by Senator Alquist and the Seismic Safety Commission, or to continue to play California Roulette—our mass version of the famous Russian game of chance.

Other publications from ABAG's Earthquake Preparedness Program

Land Capability Analysis For Planning and Decision Making (February 1976)

Hazards Evaluation For Disaster Preparedness Planning (February 1976)

Regional Earthquake Safety Issues and Objectives (February 1977)

Earthquake Insurance Issues (September 1977)

Earthquake Intensity and Expected Cost (February 1978)

Legal References on Earthquake Hazards and Local Government Liability (December 1978)

Will Local Governments be Liable For Earthquake Losses? (January 1979)

Attorney's Guide to Earthquake Liability (May 1979)

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